Distortion and Autocorrelation Free Arrhenius Plots in Nuclear Multifragmentation

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It has been shown that the probability P_n of emitting n intermediate mass fragments (IMFs) can be reduced to the probability of emitting a single fragment through the binomial equation [1]. The extracted elementary emission probabilities p were also shown to give linear Arrhenius plots when $\log 1/p$ is plotted vs $1/\sqrt{E_t}$. In the hypothesis that the temperature T is proportional to $\sqrt{E_t}$, these linear Arrhenius plots suggest that p has the Boltzmann form $p \propto \exp(-B/T)$ [1]. This *experimental* observation holds for many different reactions from reverse to normal kinematics and almost over the complete intermediate energy range.

The appeal of this comprehensive picture is marred by a number of open problems. So far, the binomial decomposition has been performed on the Z-integrated fragment multiplicities (IMF), typically associated with $3 \leq Z \leq 20$. Thus, the Arrhenius plot generated with the resulting one fragment probability p is an average over a range of Z values. A second "problem" lies in the transformation between the excitation E^* to the transverse energy E_t. It was shown that if the width associated with this transformation is too large, than the linearity of the Arrhenius plots constructed with the elementary probability p would be lost in the process [3]. While both binomial parameters p and m are individually susceptible to this problem, the product of the two, $\langle n \rangle = \langle mp \rangle$ has been shown to be very resilient to the averaging process [3]. Finally, the fact that IMFs as a category can contribute a fair amount to E_t, about 30% maximum for the Xe+Au at 50A MeV, has been pointed out as a possible source of autocorrelation between p and $\sqrt{E_t}$ leaving its interpretation questionable [4,5].

While the last two "problems" can be argued on the basis of the existing analysis [6], all of the above can be avoided by doing an analysis of the mutiplicities for each fragment of charge Z [2]. For such an analysis, we have shown [2] that the multiplicity distributions are Poissonian and therefore reducible. The average yield per event $\langle n_Z \rangle$ gives linear Arrhenius plots as a function of $1/\sqrt{E_t}$. However, $\langle n_Z \rangle$ is now free of any distortion due to possible averaging going from E^* to E_t [3]. Also, because of the dominance of the zero fold probability, the contribution of a particular Z to E_t is very small $\leq$ 5%. Still, to be sure that there is no autocorrelation, we have repeated the analysis for Xe+Au at 50A MeV by: i) removing from E_t all contributions from the individual Z that we have selected (Fig. 1). ii) by using only the E_t of the light charge particles (Fig. 2). In both cases, the Arrhenius plots remain linear over 1 to 2 order of magnitude. These results are similar to those using the total E_t and therefore we conclude that the linearity of the Arrhenius plots is due to a dominant phase space (thermal/statistical) emission process.

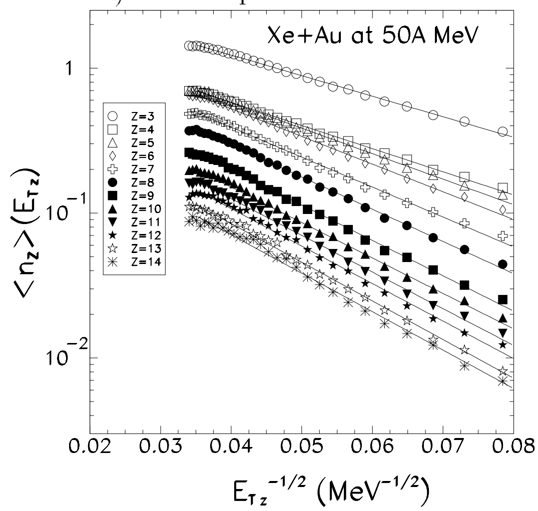

FIG. 1. The average yield per event of the different indicated elements (symbols) as a function of $1/\sqrt{E_t}$ for the Xe+Au reactions at 50A MeV. The transverse energy, E_t, is calculated for all charged particles excluding the individual Z we have selected. The lines are linear fits to the data.

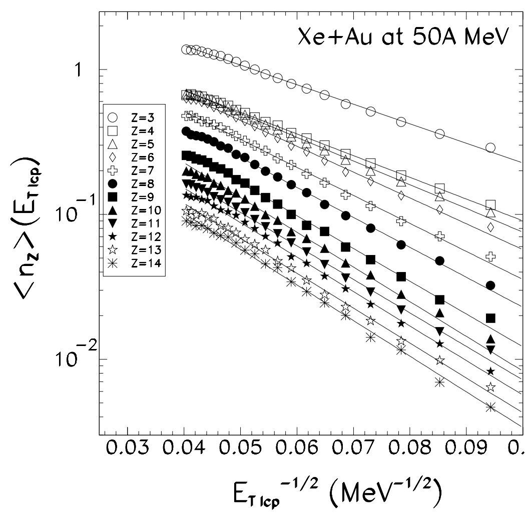

FIG. 2. Same as Fig. 1 but now E_t is calculated only from the light charged particles (LCPs).

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[2] L. Beaulieu *et al.*, LBNL-41075, submitted to Phys. Rev. Lett. See also the contribution to this annual report.
[3] J. Toke *et al.*, Phys. Rev. C **56**, R1683 (1997).
[4] M.B. Tsang *et al.*, accepted, Phys. Rev. Lett.
[5] W. Skulski *et al.*, to appear in Proc. 13th Workshop on Nuclear Dynamics, Key West, Florida (1997).
[6] L. Phair *et al.*, to be published. See also http://csa5.lbl.gov/moretto/